BOON & BROWN

The System of Electrical
Distribution at the
University of Illinois

Electrical Engineering
B.S.
1911

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THE SYSTEM OF ELECTRICAL DISTRIBUTION AT THE UNIVERSITY OF ILLINOIS

BY

ELVIN EDWARDS BOON
HUGH ALEXANDER BROWN

THESIS

FOR THE

DEGREE OF BACHELOR OF SCIENCE
IN
ELECTRICAL ENGINEERING

COLLEGE OF ENGINEERING
UNIVERSITY OF ILLINOIS
1911

1911
B64

UNIVERSITY OF ILLINOIS

May 29 1911

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Elvin Edwards Boon and Hugh Alexander Brown

ENTITLED The System of Electrical Distribution at the University of Illinois

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science in Electrical Engineering

Arthur C. Hobble
Instructor in Charge

APPROVED: Ernst Berg

HEAD OF DEPARTMENT OF Electrical Engineering.

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THE SYSTEM OF ELECTRICAL DISTRIBUTION AT THE UNIVERSITY OF ILLINOIS.

INTRODUCTION.

This thesis is Part Two of the report on the Electrical system at the University of Illinois. In the present thesis, involving the work of writing a some what detailed report on the distribution, three principal objects were kept in view; first, to collect all data obtainable on the feeders running from the power house to the different buildings, and the electrical equipment in the buildings; second to collect such data as would be necessary for the calculation of operating characteristics and economies; and third to make such recommendations as would tend to improve existing conditions.

The University distribution system is two phase, four wire, 60 cycles, 440 volts. A four wire feeder cable runs from the switch board to each building or group of buildings. The manner in which these feeders are connected to the bus-bars on the switch boards is shown in the thesis of Messrs. J.H. Trueman and J.K. Burns, entitled "The Electrical Power Plant of the University of Illinois."

From the switch board the feeder cables run to various distribution points thru a system of tunnels which also contain the low pressure steam heating mains to various buildings.

1- Data on Feeders, Circuits, and Electrical Equipment.

On the following sheets is compiled all the data collected, together with an assembled drawing of the circuits, map of the grounds and photographs of some of the principal buildings.

FEEDER NO.1.

AGRICULTURE BUILDING...

1- Lighting.

(a) System of Distribution.

Both Phases of 2-phase 60 used- 3 wire 220 volt distribution from each Transformer.

(b) Loups.

725 Columbia 16 cp. 220 volt Carbon Filament.

2 Columbia 8 cp. 220 volt Carbon Filament.

(c) Total lighting load Agriculture building 39.6 K.W.

2- Power.

(a) System.

2 phase, 60 cycle, 440 volts.

(b) Motors.

1-15 HP	400 Volt	19 Amp	60 Cycle	690 RPM	Westinghouse	Type"C"
1- 5 HP	400 Volt	14.6 Amp.	60 Cycle	1100 RPM	" "	" "C"
1- 5 HP	400 Volt	6.15 Amp.	60 Cycle	1700 RPM	" "	" "CCL"
1- 5 HP	400 Volt	6.5 Amp.	60 Cycle	1120 RPM	" "	" "CCL"
1- 5 HP	400 Volt	5.8 Amp.	60 Cycle	1700 RPM	" "	" "CCL"
1- 3 HP	400 Volt		60 Cycle		" "	" "CCL"
1- 90 Watt	220 Volt		60 Cycle	Desk Fan		
1- 1/4 HP	220 Volt		60 Cycle	Single Phase Gen. Electric.		
1- 1/4 HP	220 Volt		60 Cycle	Single Phase Century.		

(c) Total Motor Load Agriculture Building.......

.....................................39.33 KW

3- Total connected load Agriculture Building 78.93 KW

4- Transformers-

1- 2 KW, 60 Cycle, O.C. Wagner Auto 440-220 V

1- 2 KW, 60 Cycle, O.C. Lakon Auto 440-220 V

Neutrals of each connected and grounded.

FEEDER NO. 1

AUDITORIUM...

1- Lighting.

(a) System.

Both phases of 2-phase, 60 cycle used, 110 volt six wire distribution from each transformer.

(b) Lamps.

1170 Columbia 16 cp. 110 volt Carbon filament.

(c) Total lamp load, Auditorium............64.3 KW

2- Motors. None

3- Transformers.

2- O.C. 4 KW 440-110 Wagner Auto.

FEEDER NO. 1

FARM BUILDINGS......

1- Lighting.

(a) System.

Agronomy Bldg. 220V 3 Wire distribution on one phase

Farm Mechanics 220V 3 Wire distribution on one phase

Dairy & Horse Barns
110V distribution on one phase

Beef Cattle Barns
220V 3 Wire distribution on one phase

(b) Lamps.

Agronomy-20 Columbia 16 cp. 220V Carbon Filament

Farm Mechanics
75 Columbia 16 cp. 220C Carbon Filament

Dairy & Horse Barns
62 Columbia 16 cp. 110V Carbon Filament

Beef Cattle
40 Columbia 16 cp. 220V Carbon Filament

Horticulture
36 Columbia 16 cp. 220V Carbon Filament

Green House
27 Columbia 16 cp. 220V Carbon Filament

(c) Lighting Load Farm Buildings...........14.3 KW

2- Power.

(a) System,- 440 Volt, 2-phase, 60 cycles.

(b) Motors- Agronomy

1-15 HP 400V 19 AMP 60 Cycle 1120 RPM Westinghouse Type "C"

1-5 HP 400V 12.3 AMP 60 Cycle 1700 RPM Westinghouse Type "CCL"

Farm Mechanics

1- 15 HP 400V 19 AMP 60 Cycle 1120 RPM Westinghouse Type "C"

Beef Cattle

1- 15 HP 400V 10 AMP 60 Cycle 1120 RPM Westinghouse Type "C"

(c) Total Motor load, Farm Buildings...............49 KW

(d) Total connected Motor load

Farm Buildings..................................63.3 KW

FEEDER NO.1

FARM BUILDINGS......

3- Transformers.

(a) Agronomy and Farm Mechanics.

1- 2 KW 440-220 O.C. Wagner Auto

(b) Dairy and Horse Barns.

1- 2 KW 440-110 O.C. Wagner Auto

(c) Beef Cattle.

1- 2 KW 440-110 O.C. Wagner Auto

(d) Horticulture.

1-2 KW 440-110 O.C. Wagner Auto

(e) Green House

1-2 KW 440-110 O.C. Wagner Auto.

FEEDER NO. 2

CHEMISTRY BUILDING........

1- Lighting.

(a) System.

Both phases of 2 phase, 60 cycle used, single-phase 3 wire 220 volt distribution.

(b) Lamps.

600 Columbia 16 cp. 220 Volt Carbon Filament.

(c) Total lighting load Chemistry Building....... 33 KW

2- Power.

(a) System.

2-phase, 440 volts, 60 Cycle.

(b) 1-20 HP 400 V 60 Cycle 22 Amp. Westinghouse "CCL" Fan Motor.

1-3 HP 400 V 60 Cycle 3.8 Amp. Westinghouse "C" Motor-Gen Set.

(c) Total connected motor load Chemistry Bldg.....20 KW

3- Total Load, Chemistry Building.....................53 KW

4- Transformers.

(a) 2- O.C. 2 KW 440-220,60 Lakon Auto Located in basement near tunnel, Secondaries grounded Neutrals connected.

5- Storage Battery-

20 cell, 160 amp-h o 75 volt storage battery- lead plate.

FEEDER NO. 3

OLD NATURAL HISTORY BUILDING.

1- Lighting.

(a) System of Distribution.

220 volt 3 wire distribution from one phase.

(b) Lamps.

795 Columbia 16 C.P. 220 volts Carbon filament.

(c) Total connected lighting load.................43.7 KW

2- Motors.

3- Transformers.

1- 2 KW O.C. Wagner Auto. 440-220 volts.

Grounded Neutral.

FEEDER NO.3

NEW NATURAL HISTORY BUILDING.

1- Lighting.

(a) System of Distribution.

Both phases of 2-phase 60 cycles used.

2- wire 110 volt 2 wire distribution from each.phase.

(b) Lamps

36 Columbia 16 C.P. 110 Volts carbon filament

1171 Columbia and G.E.Mazda 20 watt Tungsten

(c) Connected lighting load Nat. Hist., 25.3 K.W.

2 Power:

(a) System: 2 phase, 60 cycle, 440 volts used.

(b) Motors:

1-30 H.P. 400 volt 19 Amp. 690 RPM Westinghouse type "C"

1-30 H.P. 400 volt 14 Amp 1200 RPM Westinghouse type "CCL"

(c) Connected motor load, Nat. Hist. 30 K.W.

(d) Total connected load, New Nat. Hist. 55.3 K.W.

3. Transformers:

2-15 K.W. O.C. Wagner 440-110 volts transformers.

FEEDER NO. 3

LAW BUILDING AND MAIN HALL.

1. Lighting.

(a) System

Law Building-220 volt, 3-wire distribution.from 1 phase.

Main Hall- 220 volt, 3-wire distribution from 1 phase

(a) Lamps.

(Law Building,- 156 Columbia 16 C.P. 220 volt, carbon filament.

Main Hall,- 520 Columbia 16 C.P. 220 volt, carbon filament.

(c)Total connected lighting load Main Hall and Law Bldg.- 37.2 K.W.

(2.) Motors -None

(3) Transformers.

Law Bldg.-1-2 K.W. O.C. Wagner Auto., 440-220 volts.

Main Hall-1-2 K.W. O.C. Wagner Auto., 440-220 volts.

Neutrals of each connected together and grounded.

FEEDER NO. 4.

WOMAN'S BUILDING.

1. Lighting.

(a) System.

Both phases of 2-phase, 60 cycle used.

Single-phase, 3 wire distribution from each transformer at 220 volt.

(b) Lamps.

381 Columbia 16 C.P. 220 volts carbon filament.

2. Power.

(a) Motors.

(b) Total connected load, Woman's Bldg.,,,20.9 K.W.

3. Transformers.

1 O.C. 2 K.W. Wagner 440-220 volts. Auto.

1 O.C. 2 K.W. Lakon 440-220 volts. Auto.

Neutrals connected and grounded.

FEEDER NO. 5

PHYSICS BUILDING.

1. Lighting.

(a) System.

Both phases, 2-phase, 60 cycle used.

Single-phase 2-wire, 110 volt distribution from each transformer.

(b) Lamps.

148 20 Watt Columbia Tungstens. 110 volts.

1650 16 C.P. Columbia 110 volts carbon filament.

(c) Total connected lighting load ....93.7 K.W.

2. Power.

(a) System,- 2-phase 60 cycle 440 volts.

(b) Motors:

1-10 H.P. 400 volt 12 amp. 1200 R.P.M. Ft. Wayne, Type "M"

1-15 H.P. 400 volt 17 amp. 1200 R.P.M. Ft. Wayne, Type "M"

2- 2 H.P. 400 volt 2.3 amp.1800 R.P.M. Ft. Wayne.

1- 5 H.P. 400 volt 5 amp.1800 R.P.M. Ft. Wayne.

1-10 K.W. Motor generator set, not used.

(c) Total Motor Load, Physics Bldg............30 K.W.

(d) Total Load connected, Physics Bldg........123.7 K.W.

3. Transformers:

2-30 K.W. O.C. Wagner S.P. 440-110 volts.

1-15 K.W. O.C. Wagner S.P. 440-110 volts.

FEEDER NO. 6

LIBRARY.

1. Lighting

(a) System.

Both phase of 2-phase 60 used - single phase, 110 v 2-wire distribution from each transformer.

(b) Lamps.

215 - Mazda 20 watt Tungstens.

300 Columbia 20 watt Tungstens.

60 Mazda 40 watt Tungstens.

125 Columbia 16 cp carbon filament.

(c) Total lighting load, Library............19.6 K.W.

2. Power.

(a) System.

2-phase 60 cycle 400 volt.

(b) Machines.

1-15 H.P. 400 volt, 19 amp 60 ,1200 RPM Westinghouse "CCL"

(c) Motor Load connected Library...... ....15.2 K.W.

3. Total Connected Load Library. .. ..24.8 K.W.

4. Transformers.

4 oc. 7 1/2 K.W. 440-110 60 cycle Westinghouse located in basement-screened and secondaries grounded.

FEEDER NO. 7

PRESIDENT'S HOUSE.

1. Lighting.

   (a) System.

   One phase of 2-phase 60 cycle used.

   110 volt, 2-wire distribution from low side of single-phase transformer.

   (b) Lamps.

   80-Columbia 16 C.P. 110 volts carbon filament.

   (c) Connected lighting load President's House...4.4 K.W.

2. Power.

   No motors.

3. Transformers.

   1. O.C. 4 K.W. Westinghouse 440-110 volts.

FEEDER NO. 8.

Y.M.C.A.

1. Lighting.

(a) System.

Both phases of 2-phase 60 used-Single phase 440-220 -4 wire distribution.

(b) Lamps.

38 Sunbeam 16 cp, 55 W Carbon filament.
102 Moline 16 cp. 55 W Carbon filament.
285 Sunbeam 16 cp. 55 W Carbon filament
6 Mazda 60 W Tungsten.
30 Columbia 20 W Tungsten.

(c) Total Lighting load... ....25.4 K.W.

2. Power

(a) System-2-phase. 60 , 440 volt

No motors

3. Transformers

2 O.C. 7 1/2 K.W., 440-220-110 Wagner Auto. on wall in basement.

FEEDER NO. 9.

ENGINEERING BUILDING.

1. Lighting.

(a) System- Both phases of 2-phase 60 cycle used.

110 volt 2 wire distribution from each transformer.

(b) Lamps.

486	Columbia	16 cp.	Carbon filament
5	Mazda	100 W	Tungsten
112	Columbia	25 W	Tungsten
64	Columbia	40 W	Tungsten
18	Mazda	20 W	Tungsten
7	Mazda	40 W	Tungsten
3	Columbia	50 cp.	Carbon filament.

(c) Total lighting load connected.........32.65 K.W.

2. Power- No motors.

3. Transformers

2	O.C.	4 K.W.	440-110	60	Westinghouse
1	O.C.	5 K.W.	440-110	60	Westinghouse
1	O.C.	5 K.W.	440-110	60	Wagner

Located under floor 30 ft. from tunnel entrance-

screened but in accessible.

FEEDER NO.10

HYDRAULICS LABRATORY....

1- Lighting.

(a) System.

One phase of 2-phase 60 cycle used.

220 volt 3 wire distribution.

(b) Lamps.

115 Columbia 16 C P 220 volts carbon filament.

(c) Total connected lighting load....... .... 6.32 KW

2- Power

(a) System.

Both phases, 2 phase 60 Cycle 440 Volts used.

(b) Motors

2 10 HP 440 volt G.E. Type "10" 1200 R.P.M.

1 15 HP 440 volt G.E. Type "10" 1200 R.P.M.

(c) Connected motor load Hydraulics Labratory....32.5 KW

(d) Total connected load Hydraulics Labratory....38.8 KW

3- Transformers

1 O.C. 2 K.W. Lakon Auto trans 440-220 volts.

Grounded neutral.

FEEDER NO. 11

BOILER ROOM AND WATER STATION.

1- Lighting.

(a) System.

One phase, 2-phase, 60 cycles used.

220 volt, 3 wire distribution from 1 phase.

(b) Lamps

40-Columbia 16 C.P. 220 volt, carbon filament.

(c) Connected lighting load, Boiler Room and Water Station.. 2.2 KW

2- Power.

(a) System.

2-phase, 60 cycle, 440 volts.

(b) No motors.

3- Transformers.

1- O.C. 1 K.W. G.E. Auto Trans. 440-220 volts.

Neutral not grounded.

FEEDER NO. 11

CERAMICS BUILDING.....

1- Lighting.

(a) System

Both phases, 2-phase, 60 cycle used.

110 volt, 2 wire distribution from each phase.

(b) Lamps.

76- Columbia 16 C.P. 110 volt carbon filament.

(c) Connected lighting load Ceramics Building..... 4.18 KW

2- Power.

(a) System

Both phases 2 phase 60 cycle 440 volts used.

(b) Motors

1-10 HP 400 volt Westinghouse Type "CCL" 1120 R.P.M.
13.2 Amp.

Four small electric furnaces....................

Total consumption................................ .7 KW

(c) Connected motor and furnace load Ceramics....... 11 KW

(d) Total connected load Ceramics Building..........15.2KW

3- Transformers

2- O.C. 2 K.W. Wagner 440-110 volts.

FEEDER NO. 11

M.E. LABoRATORY....

1- Lighting.

(a) System

One phase of 2-phase 60 cycle used.

220 volt 3 wire distribution.

(b) Lamps

168- Columbia 16 C.P. 220 volt, carbon filament.

(c) Connected lighting load M.E. Labratory.......... 9.2 KW

2- Power.

(a) System

2-phase, 6p cycle, 440 volts.

(b) Motors

2-10 HP 400 volt 1120 Westinghouse, Type "F"

1- 10 HP 400volt 900 Westinghouse Type "F"

1- 2 HP 400 volt 2 1/2 Amp 1800 RPM Gen. Elec.Type I

(c) Connected Motor load, M.E. Labratory............30.0 KW

(d) Total connected load M.E. Labratory............39.2 KW

3- Transformers.

1- O.C. 2 K.W. Wagner Auto Trans. 440-220 volts.

Neutral grounded.

FEEDER NO. 12

MEN'S GYMNASIUM........

1- Lighting.

(a) System

Both phases of 2-phase, 60 cycle used. Single phase 220 3 wire distribution.

(b) Lamps.

252 Columbia 16 cp. Carbon filament.

12 Nernst Lamps.

(c) Total lighting load Gymnasium..................20.4 KW

2- Power None

(a) Motor load None

3- Total load Gymnasium.............................20.4 KW

4- Transformers.

2-2 K.W. O.C. 440-220 V. Lakon Auto located under floor, neutrals connected, secondaries grounded.

FEEDER NO. 13

WOOD SHOP......

1- Lighting.

(a) System

Both phases of 2 phase 6p cycle used- single phase 3 wire 220 volt distribution.

(b) Lamps

170 Columbia 16 cp. carbon filament

(c) Total Lighting Load, Wood Shop .... 9.35 KW

2- Power.

(a) System

2 phase, 400 volt, 60 cycle.

(b) Motors

1-10 HP 400 V 15.7 Amp. 60 Cycle 1120 R.P.M. Westinghouse Type "C"

1-75 HP 400 V 10 Amp. 60 Cycle 1200 R.P.M. Westinghouse Type "CCL"

2-5 HP 400 V 6.5 Amp. 60 Cycle 1120 R.P.M. Westinghouse Type "C"

(c) Total Motor Load Wood Shop.................. 31 K.W.

4- Transformers.

1-O.C. 2 KW 440-220 Wagner Auto fastened to brick wall over tunnel, screened and secondaries grounded.

FEEDER NO. 14

METAL SHOPS......

1- Lighting.

(a) System

Both phases of 2-phase, 60 cycle used-

Single phase 2 wire 110 volt distribution.

(b) Lamps

118 Columbia 16 cp. carbon filament.

(c) Total lighting load Metal Shops.............6.5 KW

2- Power.

(a) System

2-phase, 400 volt, 6p cycle used.

(b) Motors

1-25 HP 400 V 29 Amp. 60 Cycle 1200 R.P.M. Westinghouse
Type "CCL"

1-7.5 HP400 V 9.7 Amp.60 Cycle 840 R.P.M. Westinghouse
Type "C"

1-5 HP 400 V 7 Amp.60 Cycle 1700 R.P.M. Westinghouse
Type "CCL"

1-75 HP 400 V 8.2 Amp. 60 Cycle 1700 RPM Westinghouse
Type "CCL"

1-10 HP 400 V 3 Amp. 60 Cycle 850 R.P.M. Westinghouse
Type "CCL"

(c) Total Motor load Metal Shops...............53.6 KW

3- Total Load Metal Shops..........................60.1 KW

4-Transformers.

1-O.C. 5 KW 440-110 Westinghouse located in basement fastened to wood post. Secondaries of each phase connected. Two wire distribution.

FEEDER NO.15

E.E. LABRATORY......

1- Lighting.

(a) System of Distribution.

Both phases of 2-phase, 60 cycles used,

110 volt 2-wire distribution from each transformer.

(b) Lamps

4- 32 cp. Columbia, 110 volt, carbon filament.

13- 20 Watt Mazda 110 volt, Tungstens.

314- 16 cp. Columbia, 110 volts, carbon filament.

(c) Total connected lighting load 17.84KW

2- Power.

(a) System

2-phase, 60 cycles, 440 volts.

(b) Motors

1- motor generator set with 45 KW synchronous motor on A.C. side.

1- Westinghouse desk fan in office.

1-10 HP Westinghouse "Type CCL" 440 volts 1100 RPM

(c) Connected motor load.......................... 54 KW

(d) Total Connected Load E.E. Labratory...........71.8 KW

3- Transformers

2- Westinghouse O.C., 4 KW transformers, 440-110 volts for lighting.

2-Westinghouse O.C. 8 KW transformers, 440-220-110 volts for labratory experimental work.

FEEDER NO. 16

NEW POWER HOUSE.......

1- Lighting.

(a) System

3-phase 110 volt, 3 wire distribution from three-phase transformer.

(b) Lamps

64 Columbia 16 cp. carbon filament.

4 Mazda 60 Watt Tungsten.

(c) Lighting Load..... Total......................3.76 KW

2- Power.

(a) System

2300-110 volt 3 phase, 3 wire 60 cycles

(b) Motors None

3- Total Load, Power House.........................3.76 KW

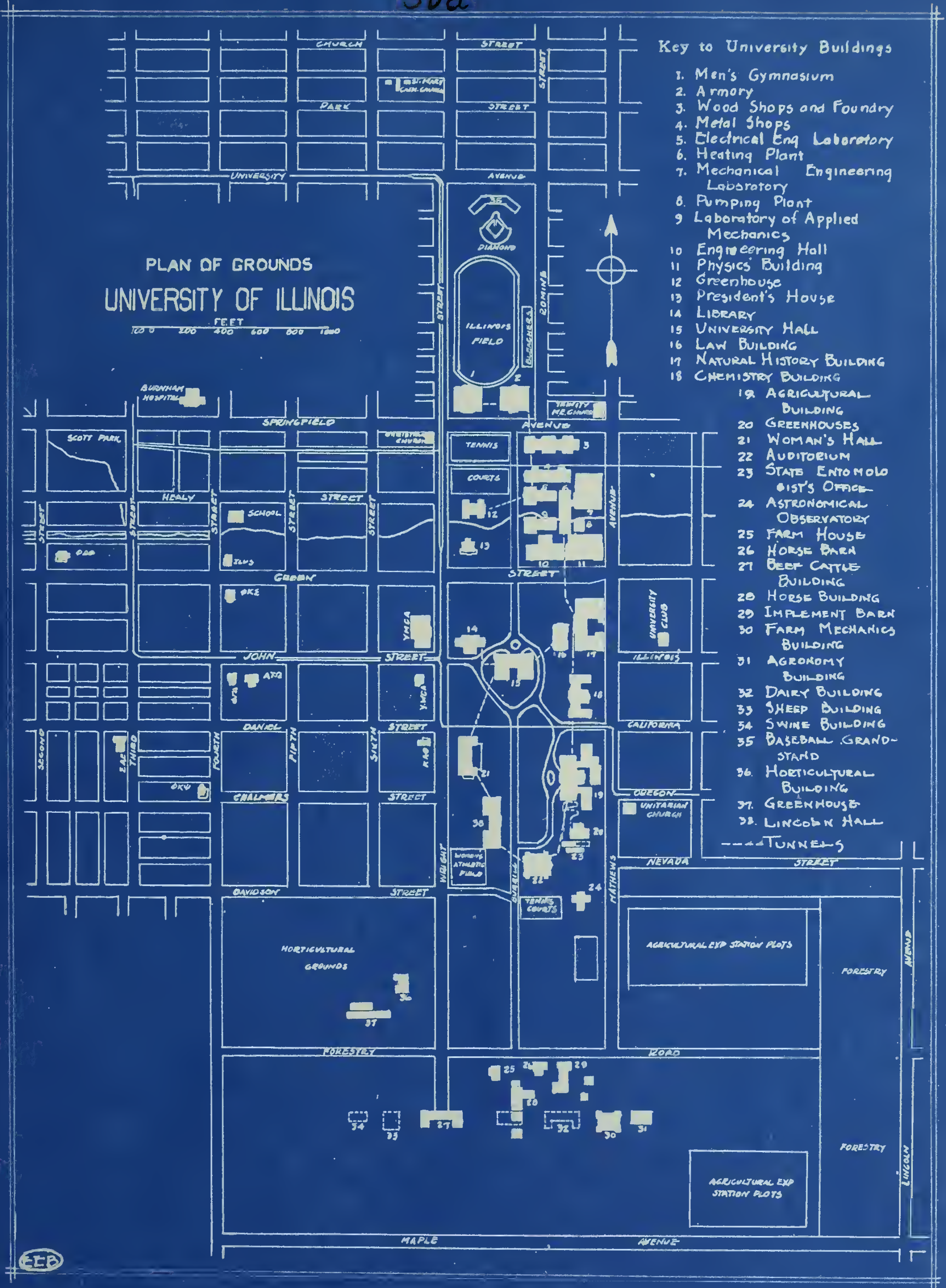
4- Transformers.

1- O.C. 2300-110 Westinghouse 3-phase

DISTRIBUTION OF FEEDER CIRCUITS.

Circuit Number	Bldgs. on Circuit	Trans-former Capacity	Lighting load total	Motor Load total KW	Total Load KW	Average Load for 24Hrs. KW
1	AG&Farm Bldgs.	12.0	62.3	88.93	150.63	6.35
	Auditorium	8.0	64.3	0	64.3.	
2	Chemistry	4.0	33.0	20.0	53.0	8.33
3	Old Nat.His.	32.0	68.85	30.0	98.85	
	New Nat.His.					10.2
	Law	2.0	8.85	0	8.58	
	Main Hall	2.0	28.62	0	28.62	
4	Woman's Bldg.	4.0	20.9	0	20.9	4.03
5	Physics Bldg.	41.5	93.7	30.0	123.7	5.52
6	Library	30.0	19.6	15.2	34.8	12.1
7	Pres. House	4.0	4.4	0	4.4	
8	Y.M.C.A.	15.0	25.4	0	25.4	2.08
9	Eng. Bldg.	14.0	32.65	0	32.65	2.12
10	Hydraulics Lab.	2.0	6.32	32.5	38.82	2.06
11	Boiler Room	1.0	2.2	0	2.2	
	Water Sta.					13.9
	Ceramics	4.0	4.2	11.0	15.2	
	M.E. Lab.	2.0	9.2	30.0	39.2	
12	Men's Gym	4.0	20.4	0	22.1	.76
	Armory	1.0	1.7			
13	Wood Shop	2.0	9.35	31.0	40.35	3.8
14	Metal Shops	5.0	6.5	53.6	60.1	5.32
15	E.E. Lab.	8.0	17.8	54.0	71.8	1.77
16	New Power Plant	5.0	3.76	0	3.76	
17	Deep Wells		0	30.0	30.0	6.0
	Totals	182.5	543.73	425.63	969.36	

Note- Average Load Figures From Watt Hour Meter Readings.


CHURCH STREET
PARK STREET
UNIVERSITY AVENUE
ST. MARY'S CATH. CHURCH
DIAMOND
ILLINOIS FIELD
BLEACHERS
WRIGHT STREET
ROMINE STREET
FEET
100 0 200 400 600 800 1000
BURNHAM HOSPITAL
SPRINGFIELD AVENUE
TRINITY ME CHURCH
SCOTT PARK
HEALY STREET
SCHOOL
TENNIS COURTS
GREEN STREET
JOHN STREET
DANIEL STREET
CHALMERS STREET
DAVIDSON STREET
SECOND
THIRD
FOURTH
FIFTH
SIXTH
YMCA
UNIVERSITY CLUB
ILLINOIS
CALIFORNIA
OREGON
UNITARIAN CHURCH
NEVADA STREET
MATHEWS AVENUE
WOMEN'S ATHLETIC FIELD
BURRILL
TENNIS COURTS
HORTICULTURAL GROUNDS
AGRICULTURAL EXP STATION PLOTS
FORESTRY
FORESTRY ROAD
MAPLE AVENUE
LINCOLN AVENUE
EEB

PLAN OF GROUNDS
UNIVERSITY OF ILLINOIS

Key to University Buildings

1. Men's Gymnasium
2. Armory
3. Wood Shops and Foundry
4. Metal Shops
5. Electrical Eng Laboratory
6. Heating Plant
7. Mechanical Engineering Laboratory
8. Pumping Plant
9. Laboratory of Applied Mechanics
10. Engineering Hall
11. Physics Building
12. Greenhouse
13. President's House
14. Library
15. University Hall
16. Law Building
17. Natural History Building
18. Chemistry Building
19. Agricultural Building
20. Greenhouses
21. Woman's Hall
22. Auditorium
23. State Entomologist's Office
24. Astronomical Observatory
25. Farm House
26. Horse Barn
27. Beef Cattle Building
28. Horse Building
29. Implement Barn
30. Farm Mechanics Building
31. Agronomy Building
32. Dairy Building
33. Sheep Building
34. Swine Building
35. Baseball Grandstand
36. Horticultural Building
37. Greenhouse
38. Lincoln Hall

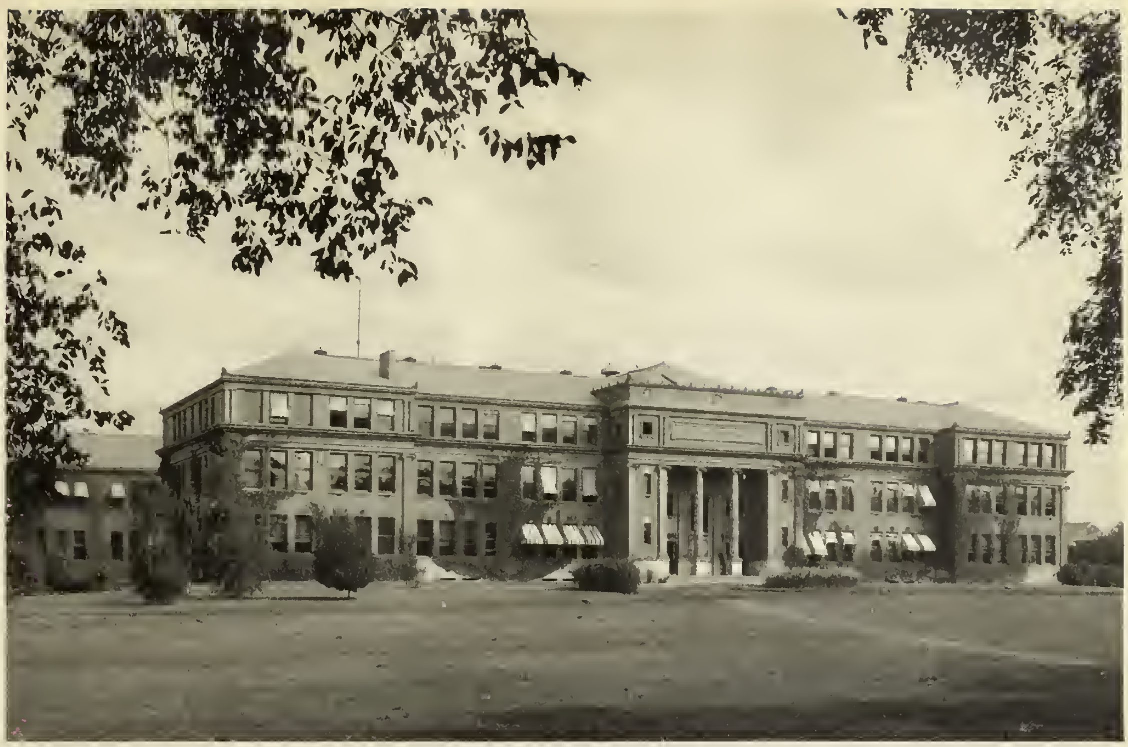
---- Tunnels

Gymnasium.

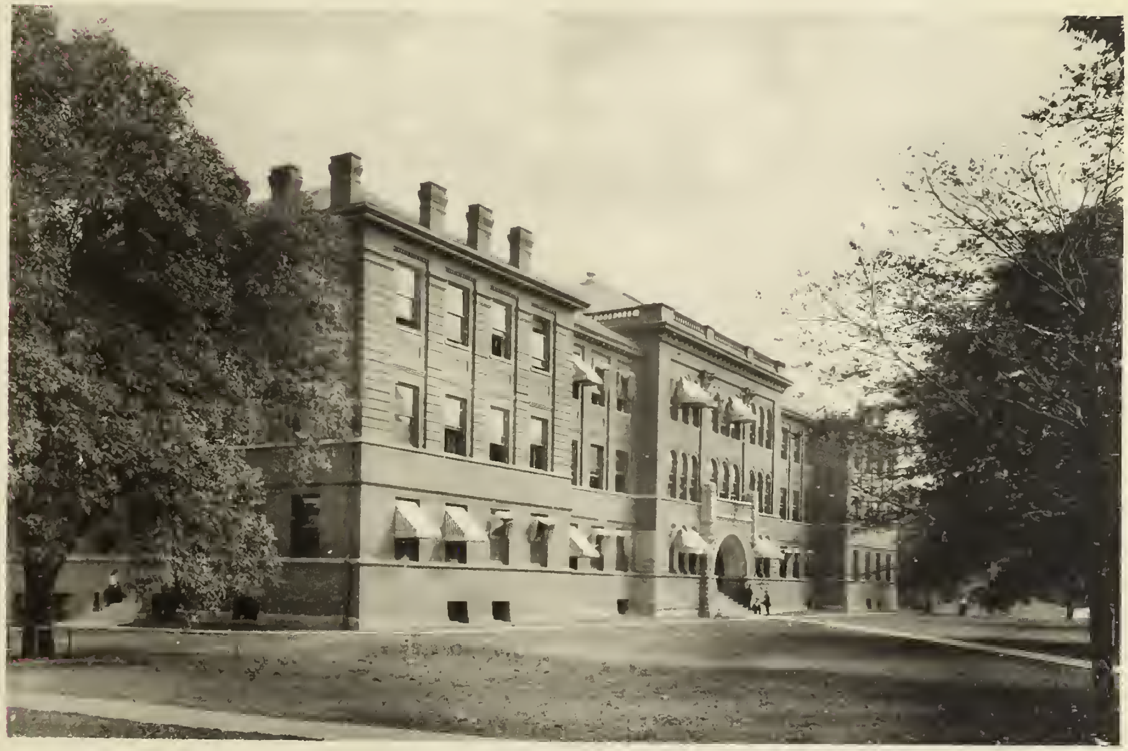
The Armory.

Young Men's Christian Association.

Auditorium.



College of Agriculture.



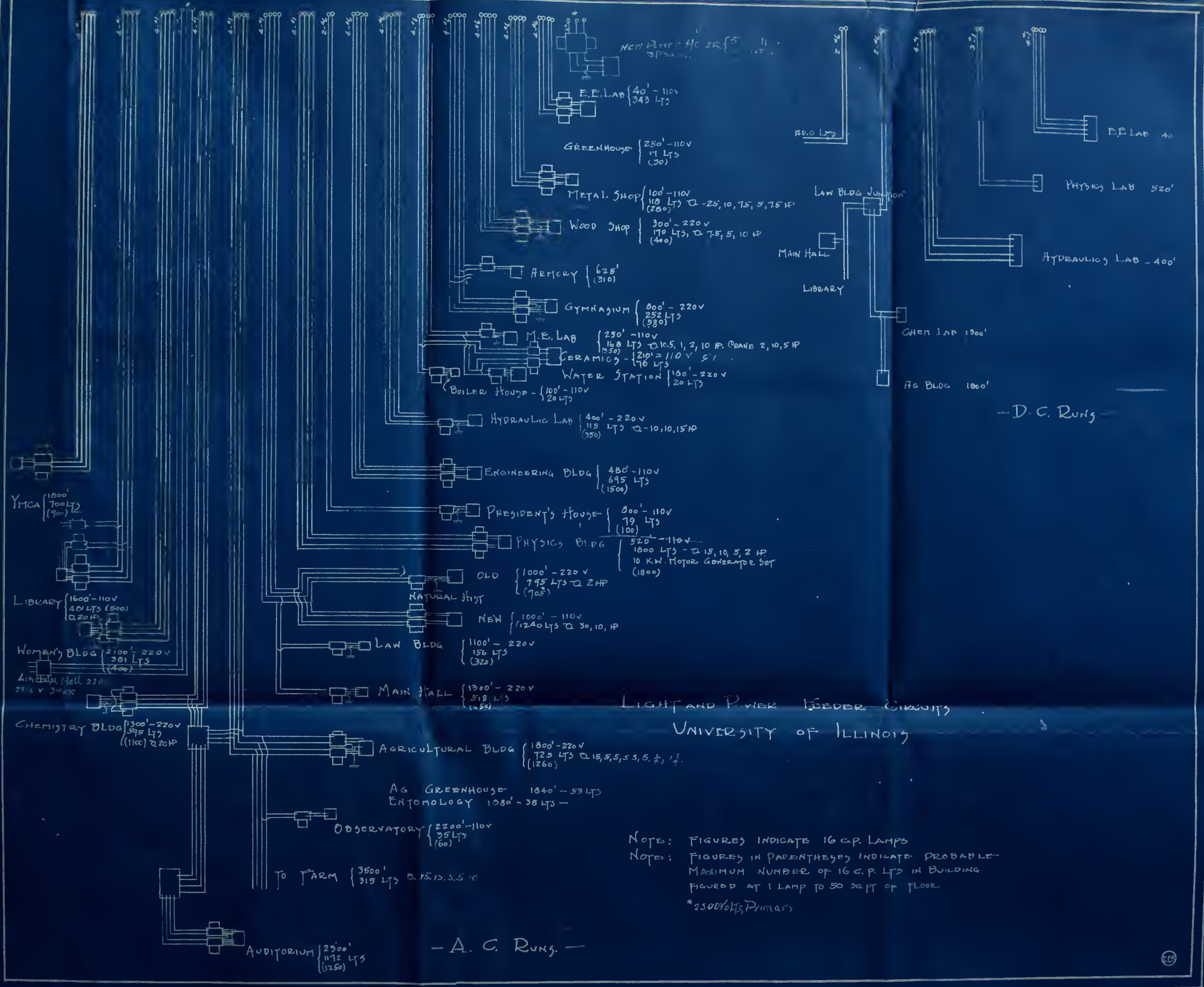
Chemistry Hall.

Natural History Hall.

Physics Laboratory

THE LIBRARY.

WOMAN'S BUILDING.



NEW POWER · HC SR {5 11 I.T.
3 Pha
E.E. LAB {40' - 110V 343 LTS
GREENHOUSE {250' - 110V 17 LTS (30)
METAL SHOP {100' - 110V 118 LTS ⩍ - 25, 10, 7.5, 5, 7.5 HP (280)
WOOD SHOP {300' - 220V 170 LTS, ⩍ 7.5, 5, 10 HP (400)
ARMORY {625' (310)
GYMNASIUM {800' - 220V 252 LTS (380)
M.E. LAB {250' - 110V 168 LTS ⩍ 10.5, 1, 2, 10 HP. CRANE 2, 10, 5 HP (350)
CERAMICS - {210' = 110 V 76 LTS
WATER STATION {180' - 220 V 20 LTS
BOILER HOUSE - {100' - 110V 20 LTS
HYDRAULIC LAB {400' - 220 V 115 LTS ⩍ - 10, 10, 15 HP (350)
ENGINEERING BLDG {480' - 110V 695 LTS (1500)
PRESIDENT'S HOUSE {800' - 110V 79 LTS (100)
PHYSICS BLDG {520' - 110V 1800 LTS - ⩍ 15, 10, 5, 2 HP 10 KW. MOTOR GENERATOR SET (1800)
OLD {1000' - 220 V 795 LTS ⩍ 2 HP (705)
NATURAL HIST
NEW {1000' - 110V 1240 LTS ⩍ 30, 10, HP
LAW BLDG {1100' - 220V 156 LTS (320)
MAIN HALL {1300' - 220 V 518 LTS (650)
AGRICULTURAL BLDG {1800' - 220 V 725 LTS ⩍ 15, 5, 5, 5 5, 5, 1/4, 1/4.
AG GREENHOUSE 1840' - 53 LTS
ENTOMOLOGY 1980' - 38 LTS -
OBSERVATORY {2200' - 110V 35 LTS (60)
TO FARM {3500' 315 LTS ⩍ 15, 15, 5, 5 10
AUDITORIUM {2500' 1172 LTS (1250)
YMCA {1800' 700 LTS (900)
LIBRARY {1600' - 110V 481 LTS (500) ⩍ 20 HP
WOMEN'S BLDG {2100' - 220V 381 LTS (400)
Lincoln Hall 220
23 ε v 3 phase
CHEMISTRY BLDG {1300' - 220V 595 LTS (1100) ⩍ 20 HP
AR.C LTS
LAW BLDG JUNCTION
MAIN HALL
LIBRARY
CHEM LAB 1300'
AG BLDG 1800'
E.E. LAB 40
PHYSICS LAB 520'
HYDRAULICS LAB - 400'
- D. C. RUNS -
- A. C. RUNS. -

LIGHT AND POWER FEEDER CIRCUITS
UNIVERSITY OF ILLINOIS

NOTE: FIGURES INDICATE 16 C.P. LAMPS

NOTE: FIGURES IN PARENTHESES INDICATE PROBABLE MAXIMUM NUMBER OF 16 C.P. LTS IN BUILDING FIGURED AT 1 LAMP TO 50 SQ FT OF FLOOR

*2300 Volts, Primary

Location of Transformers

Building	Type of Support	Protection	Location
Men's Gym.	Wood Post	No Screen	Under Basement at edge of tunnel
Armory	None		
M. E. Lab.	None	220 volt leads from station	
E. E. Lab.	Supported on brick wall	6 ft. from floor heavy screen	Small room south Basement
Metal Shop	Wood Post	No Screen	Under floor at edge of tunnel
Wood Shop	Hung on Brick Pillar	Screened	In Basement near floor joists Westend
Agriculture	Hung on outside wall	No screen	10 ft. above ground
Agriculture	Set on cement base	Screened	North end basement
Auditorium	Brick wall	In brick room with lattice door	Basement north side
Women's Bldg.	Gas Pipe rack set along wall	Screened	Basement north side
Y.M.C.A.	On plastered wall near ceiling	Screened	At foot of stairs to basement
Library	On concrete bases	Screened	Central basement
Main Hall	On plaster wall near ceiling	No Screen	Basement wall
Law Bldg.	On plaster wall	Screen	Basement south end
Chemistry	On wall	Screened	Basement hall north and south ends
Nat. Hist.	Concrete base	No screen	On floor in entry from tunnel
Physics	Concrete base	Screened	In basement hall center
Eng. Hall		Screened	Under floor at east basement
Farm	Telegraph poles		At Dairy and Greenhouse
Observatory	On poles outside		East of building
Ceramics	On cement floor	Screened	Basement near stairway
Old Nat.His.	Brick wall		Basement hall

Building	Location of Switch	Remarks
Men's Gym	No Switch	Very unsafe 440-220
Armory	D. C. Arcs.	
M. E. Lab.		
E. E. Lab.	No switch 440-110	Well protected as to life but close to second story floor
Metal Shop	440-110	
Wood Shop	Beside Transformer	440-220 Hung above tunnel
Agriculture		440-220
Agriculture	On wall 30 from Trans.	Isolated, hard to find. 440-220
Auditorium	On wall	440-220-110
Women's Bldg.	Near Trans.	440-220
Y.M.C.A.	On wall	440-220
Library	On wall	Accessible through fan room. 440-110-220
Main Hall	No switch	Dangerous as to fire 220
Law Bldg.		440-220
Chemistry	Near south transformer	Dirty 440-220
Nat. Hist.	Above trans. on wall	Very dangerous to life 440-220
Physics	Beside switch board	440-110
Eng. Hall	None	440-110
Farm	None	Wires on poles from Observatory 440-110
Observatory		440-110
Ceramics	Same	Liable to get wet should water flood basement
Old Nat. Hist.	Same	

Table showing Motors that could be changed.

Building	Size of Motor	Kind of Service	Size and type of Motor that could be used.
Agriculture	5 H.P.	Operates shakers and Mixers	2ph. 440 v 3 H.P.
Agriculture	7.5 H.P.	Operates Grinders	2ph. 440 v 5 H.P.
New Nat.His.	30 H.P.	Ventilating Fan	15-20HP.2Ph 440 v
Chemistry	20 H.P.	Ventilating Fan	15 H.P.-2ph 440 v
Ceramics	10 H.P.	Shop	5-7.5 H.P.2ph 440 v
Beef Cattle	15 H.P.	Grinders	7.5 H.P. 2ph 440 v

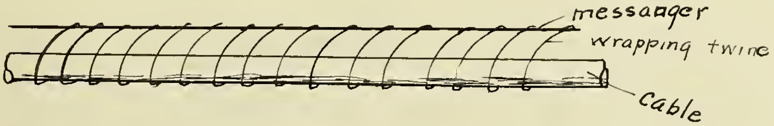
Protective Devices on High Tension Side of Transformers.

Building	
E.E. Lab.	High tension cut out fuse.
M.E. Shop	High tension cut out fuse.
Wood Shop	No device.
Armory	High tension fuses.
Gym	Autos with cut out fuse.
M.E. Lab	Switch and fuses.
Physics	Fuses
New Nat. Hist.	Switch and fuses
Old Nat. Hist.	Cut outs
Boiler Room	Cut out fuse
Hydraulic Lab	Cut out and fuse.
Main Hall	Cut out. Porcelain fused cut out
Library	Cut out and fuse.
Law	Cut out fuse.
Chemistry	Large switch and fuses also fuses for each
Ag	Switch and fuses
Auditorium	Switch and fuses.
Beef Cattle	Cut outs and fuses.
Dairy Barn	Cut outs and fuses.
Farm Mech.	Cut outs and fuses.
Horticultural	Cut outs and fuses.
Ceramics	Switch and fuses.

REPORT ON CONDITION OF CABLES.

The feeder cables to all buildings except the new Lincoln Hall are of the four conductor type, each wire having impregnated paper insulation, the four wires being covered with lead sheating.

The cables are supported from the tunnel roof by a galvanized stranded messenger cable, the lead covered cable being attached to the latter by means of 3/16" marlin hemp twine. The twine is wrapped uniformly around the cable and messenger as shown below.



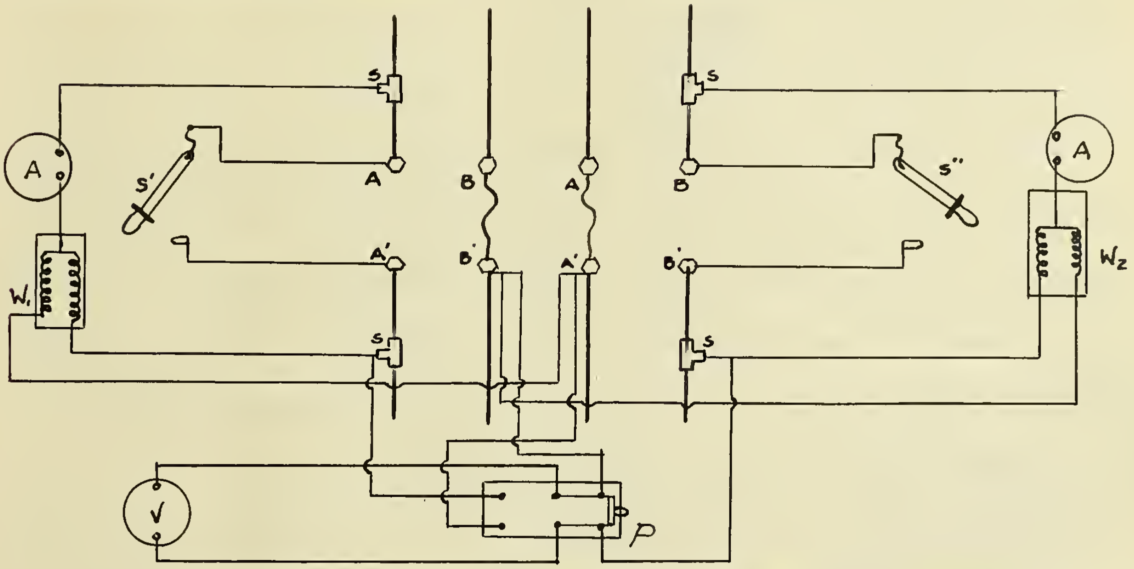
The messenger cable is hung by iron hooks screwed into gaspipe racks the latter being imbedded in the brick masonry of the tunnel. The supporting racks are about 8 ft. apart, and in such a location that the cables hang directly over and about two feet above the steam pipes. Water stands on the tunnel floor in many places. The ends of the cables are well taped i.e., the leads are wrapped with tape at the ends of the sheathing, and at these ends the sheathing is entirely plugged with tape. The ends of the sheathing are not effectually sealed against moisture. The leads to the transformers are secured to sills or joists by poreclain cleats, and in some cases pass thru the sills in common porcelain tube insulators.

-II-

Load curves, Operating Characteristics, etc.

In taking the data for a load curve on one of the feeders several difficulties were encountered. There are three generators supplying the power, and readings of volt amperes and watts could be taken from the generator meters on the switch by connecting the feeder, the load curve of which is required, to this generator, and putting all the rest of the load on the other machines. But it was found that the switch board meters were very inaccurate; since considerable accuracy is necessary for this work, accurate portable instruments had to be inserted somewhere in the feeder at the generator end of the cable. Also, since power at the recieving end was in constant demand, the meters had to be put in without breaking the circuit. Behind the switch board is a slate supporting board which carries the fuses to each feeder. The insulation was removed from a about 3/4 inch of wire on the leads on each side of one fuse in phase A, and phase B. Then by means of a special connector fastened to the leads where the insulation was removed, an ammeter and a wattmeter were shunted across the fuses. When this was done the fuses were removed, and a portable switch and fuse were connected in the place of each removed fuse.

The method of connecting will be made clearer by the following diagram:



S S are the special connectors. When the meters were connected fuses A A' and B B' were removed, and the portable knife switches with fuses were put in their places as spoken about above. These switches were kept closed and the voltmeter switch P was kept open except when reading were taken, whereupon switch S' was opened and P closed to the left; then volts, amperes, and watts were indicated on phase A by the meters on the left side in the diagram. Next S'' was opened, P closed to the right and readings were taken on phase B, using the meters on the right. The switches S' and S'' were kept closed between readings to protect the meters in case of heavy overload currents or short circuits, and to avoid any probability of a broken circuit due to loosening of the connectors of metal binding posts.

Readings were taken on one feeder every hour from 7:00 A.M. to 9 and 10:00 P.M. Readings were taken on the three heaviest feeders after which the work was abandoned because of the great risk of shocks and short circuits in connections. The fuses were only three inches apart, and the generators were grounded so that a considerable potential existed between each conductor and ground. While standing on the dry engine room floor we could get sparks by touching a fuse or connector with a pair of pliers, altho the "shock" was not noticable. If we should have happened to have stood on a nail that was driven into a damp sill while making connections, or get a ground in some other manner, the result might have been serious. Regardless of our caution, a blinding flash occurred one night when a wire touched the wrong connector, blowing a fuse. We were therefore advised to discontinue the work after three load curves were taken. The load curves taken are shown on the opposite sheet together with curves of voltage and powerfactor and current for one feeder.

The peak loads for the other feeders were determined by the method referred to at first, by connecting each feeder to a generator and reading the generator meters.

Of course these readings will not be as accurate as those taken with the portable instruments, but are close e enough to calculate the regulation of each feeder. In calculating the regulation we have given the load at the recieving end, the reciever voltage, power factor of load, and resistance of the cable. We have assumed the distribution losses in the buildings and in the branch feeders to be 2 1/2% of transformer capacity. The generator voltage is;

$$E_o = \star\sqrt{(e+ir+i_1x)^2 \quad (i_1 - i\,x)^2}$$

Where e= the reciever voltage

r= resistance of cable

x= inductance of cable

i= enegery current

i_1= wattless lagging current.

Inductance and capacity may be neglected in these cables, hence;

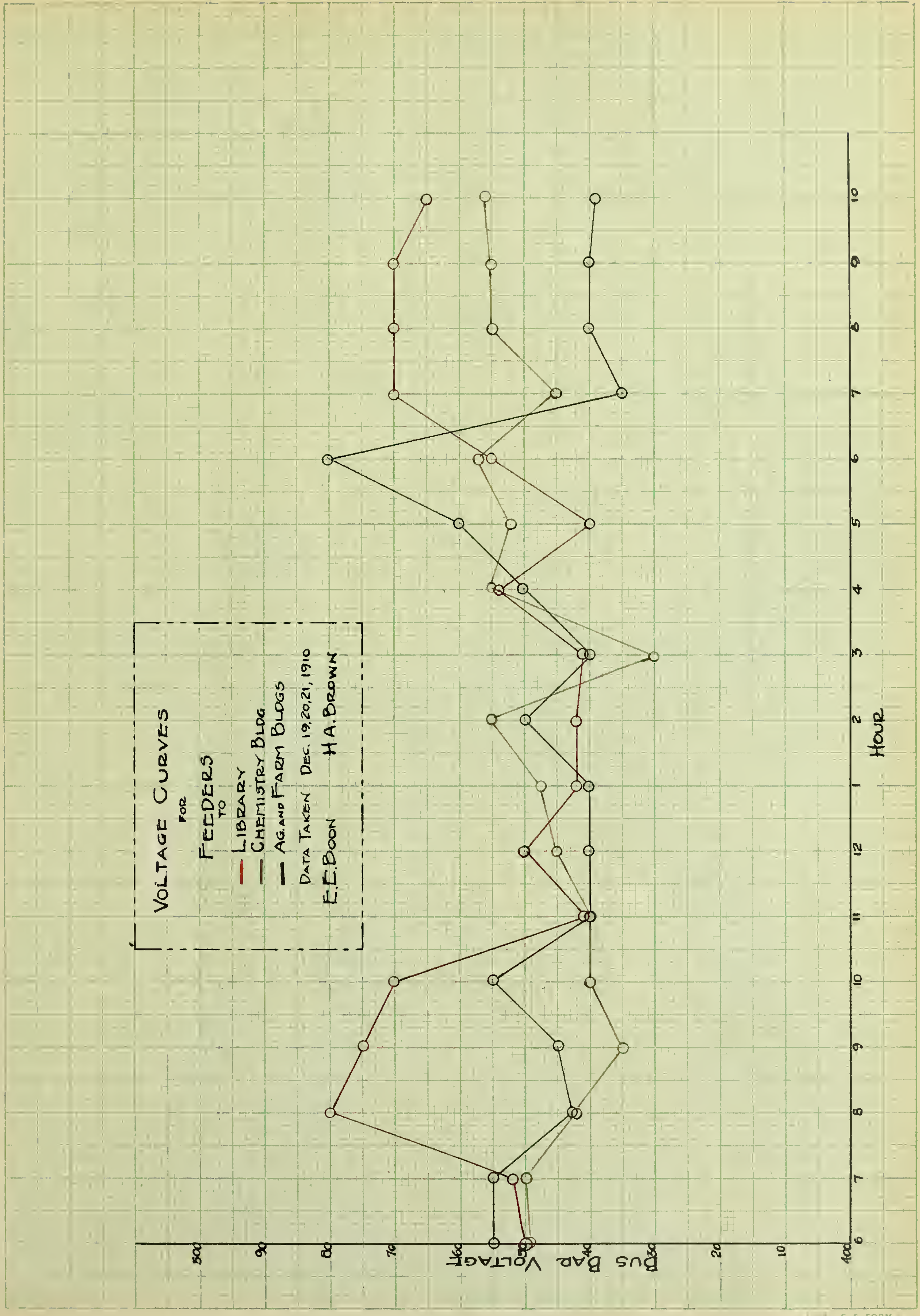
$$E_o = \sqrt{(e+ir)^2 (i_1 r\ )^2}$$

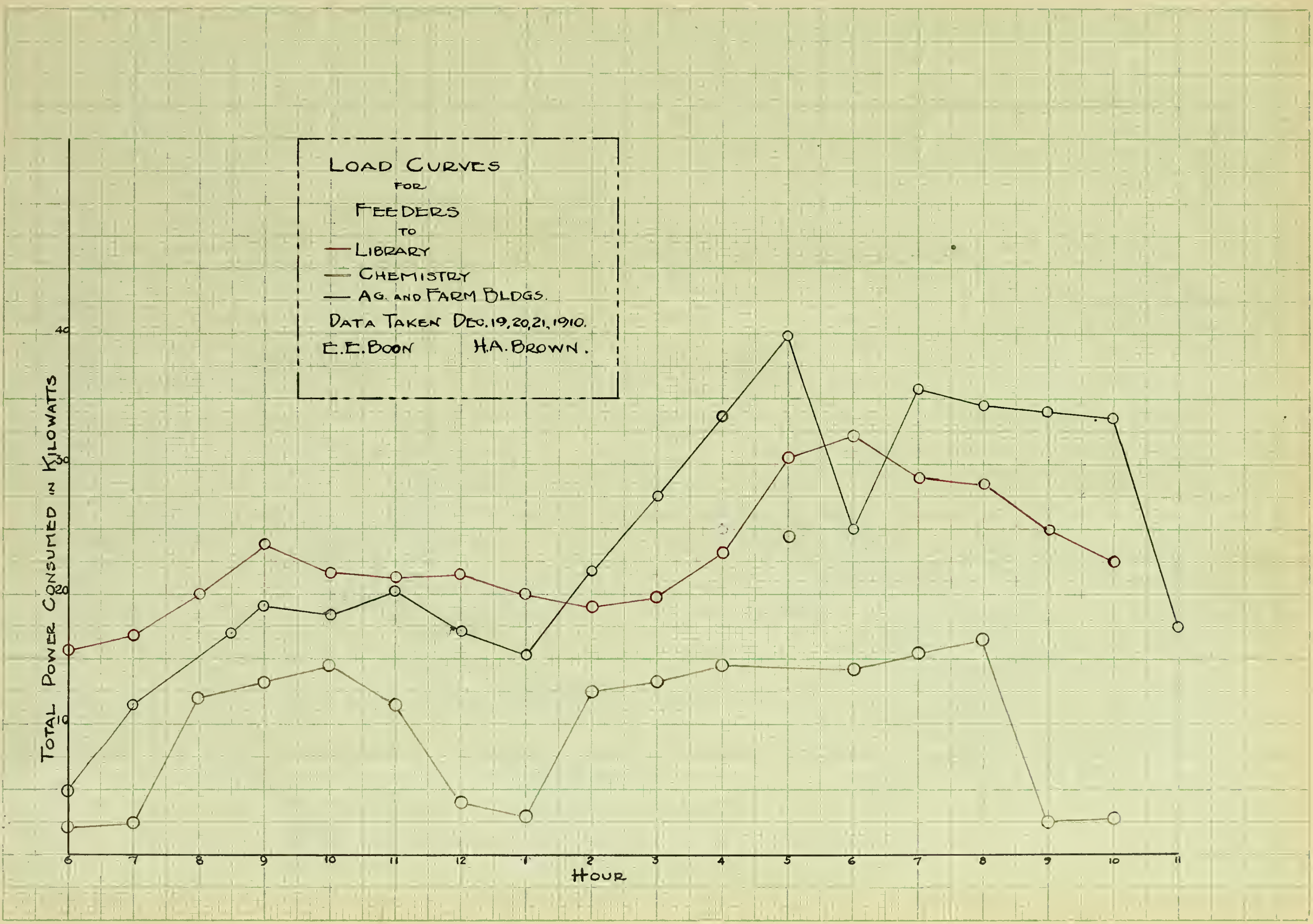
$$\text{Regulation} = \frac{E_o - e}{e}$$

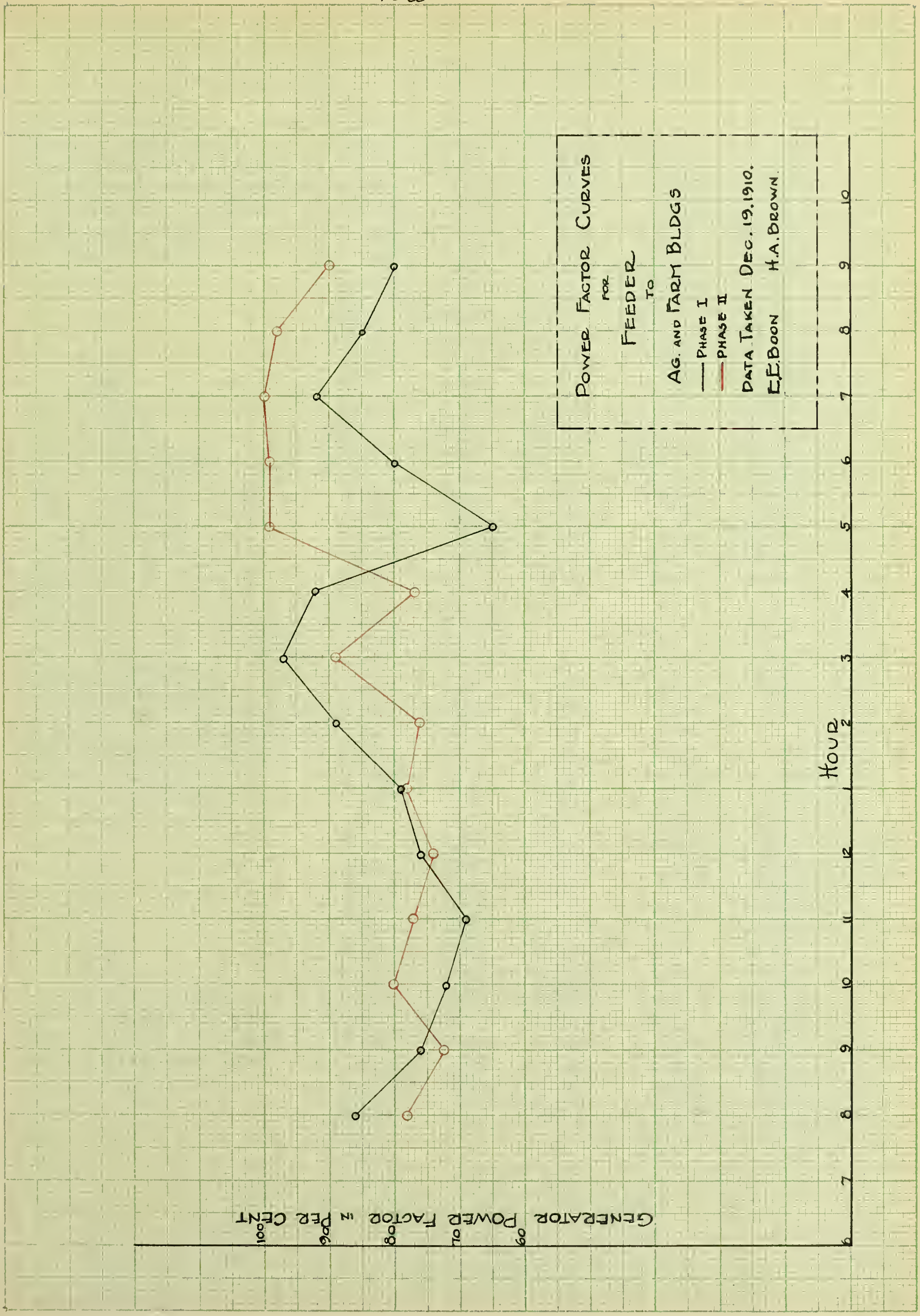
$$\text{Line efficiency} = \frac{\text{Output at rec. end.}}{\text{Output} + I^2 r}$$

I^2r = loss in cables.

On the following sheets are tables showing the calculations of regulation and efficiency for each feeder at peak load, and with maximum connected load. The calculations are made for one phase only.


VOLTAGE CURVES
FOR
FEEDERS
TO
LIBRARY
CHEMISTRY BLDG
AG. AND FARM BLDGS
DATA TAKEN DEC. 19, 20, 21, 1910
E.E. BOON
H.A. BROWN
BUS BAR VOLTAGE
400
10
20
30
40
50
60
70
80
90
500
HOUR
6
7
8
9
10
11
12
1
2
3
4
5
6
7
8
9
10
S S FORM


LOAD CURVES
FOR
FEEDERS
TO
LIBRARY
CHEMISTRY
AG. AND FARM BLDGS.
DATA TAKEN DEC. 19, 20, 21, 1910.
E.E. BOON
H.A. BROWN.
TOTAL POWER CONSUMED IN KILOWATTS
40
30
20
10
HOUR
6
7
8
9
10
11
12
1
2
3
4
5
6
7
8
9
10
11


Power Factor Curves
for
Feeder
to
Ag. and Farm Bldgs
— Phase I
— Phase II
Data Taken Dec. 19, 1910.
E.E.Boon H.A.Brown.
Generator Power Factor in Per Cent
100
90
80
70
60
Hour
6
7
8
9
10
11
12
1
2
3
4
5
6
7
8
9
10

Calculation of Regulation at Peak Loads.

No. of Feeder	1	2	3	4	5
Load at Rec. End.	20	13	17	6	12
Distribution losses	.2	.13	.17	.06	.12
Loss in branch Feeders	.2	.13	.17	.06	.12
Transformer losses	.05	.05	.38	.05	.5
Total Load-KW	20.45	13.31	17.72	6.17	12.74
Power Factor	.80	.85	.90	.90	.80
c	440	440	440	440	440
I	58.1	135.6	44.8	15.7	36.2
i	46.5	30.25	40.3	14.1	29.0
$i_,$	34.7	18.50	19.3	6.86	21.6
R	.50	.322	.320	.520	.129
iR	23.3	9.74	12.9	7.33	3.74
$i_,R$	17.4	5.95	6.18	3.57	2.79
e+ir	457.4	449.7	452.9	447.3	443.7
$(e+ir)^2+(i_,R)^2$	457.5	201630	205250	199810	196250
$E_o = \sqrt{(e+iR)^2+i_,R)^2}$	457.5	449.8	453.0	447.3	443.8
Pct Regul $=(E_o-e)\div e$	3.97	2.23	2.95	1.662	.863
I^2R in feeder KW	1.68	.408	.644	.128	.169
Line Out put KW	20.45	13.31	17.72	6.17	12.74
Line in put KW	22.13	13.72	18.36	6.30	12.91
Line efficiency %	92.3	96.9	96.5	97.7	98.3
Input to both phases KW	44.26	27.44	36.72	12.6	25.82

No. of Feeder	6	7	8	9	10
Load at Rec. End	15	.7	2	5.9	6.75
Distribution losses	.15	.007	.02	.06	.07
Loss in branch Feeders	.15	.007	.02	.06	.07
Transformer losses	.19	.1	.19	.25	.05
Total Load-KW	15.49	.814	2.24	6.27	6.94
Power Factor	.85	.90	.90	.90	.75
c	440	440	440	440	440
I	41.3	2.05	5.63	15.9	21.05
i	35.2	1.85	5.08	1.43	15.8
$i_,$	21.6	.894	2.41	3.94	14.0
R	.400	.397	.450	.630	.316
iR	14.1	.73	2.29	9.00	4.99
$i_,R$	8.64	.355	108.5	4.37	4.42
e+ir	454.1	440.7	442.3	449.0	4.45
$(e+ir)^2+(i_,R)^2$	206125	194481	195365	201605	198029
$E = \sqrt{e+iR)^2+i_,R)^2}$	454.3	440.7	442.3	449.1	445.1
Pct Regul $=(E_o-e)\div e$	2.34	.160	.52	2.07	1.16
I^2R in feeder KW	.683	.002	.014	.159	.141
Line out put KW	15.49	.814	2.24	6.27	6.94
Line in put KW	16.17	.816	2.25	6.43	7.081
Line efficiency %	95.8	99.5	99.5	97.3	98
Input to both phases KW	32.34	1.632	4.5	12.86	14.16

Peak Load, continued.

No. of Feeder	11	12	13	14	15
Load at Rec.End.	69	1	8	12	4
Distribution losses	.06	01	.08	.12	.04
Loss in branch Feeders	.06	01	.09	.12	.04
Transformer losses	.10	05	.05	.13	.10
Total Load-KW	7.12	1.07	8.21	12.37	4.18
Power Factor	.85	.90	.80	.75	.85
c	440	440	440	440	440
I	19.05	2.70	23.4	37.5	11.16
i	16.2	2.43	18.7	28.1	9.50
i_1	10.86	1.19	14.1	24.3	6.71
R	.062	.630	.237	.079	.031
iR	1.01	1.53	4.43	2.23	.295
i_1R	.067	.75	3.34	1.92	.208
$e+ir$	441	441.5	444.4	442.2	440.3
$(e+ir)^2+(i_1R)^2$	494481	194482	197136	195365	193600
$E = \sqrt{(e+iR)^2+iR^2}$	441.0	441.5	444.5	442.2	440.3
Pct Regul $=(E_o-e)\div e$	.230	.341	1.02	.50	.068
I^2R in feeder ^{o}KW	.022	.005	.130	.111	.004
Line out put KW	7.12	1.07	8.21	12.37	4.18
Line in put KW	7.14	1.075	8.34	12.48	4.184
Line efficiency %	99.6	99.7	98.5	99.2	99.9
Input to both phases KW	14.28	2.16	16.68	24.96	8.38

Regulation at Max Load.

No. of feeder	1	2	3	4
Load on feeder KW	74.9	26.2	49.3	10.5
Distribution losses 1%	.075	.03	.5	.1
Losses in branches 1%	.075	.03	.5	.1
Transformation Loss $2\frac{1}{2}$%	.05	.05	.38	.05
Total Load KW	75.1	26.3	50.7	10.7
P.F.	.9	.9	.9	.9
E	440	440	440	440
I	190	66.4	128	27
i	171	59.8	115	24.3
i,	82.5	28.5	55.8	11.8
R	.50	.322	.320	.52
iR	85.5	19.3	41	12.6
i,R	41.3	9.18	17.8	6.13
e+ir	525.5	459.3	481	452.6
$(E\ iR)^2 + (i,R)^2$	2.77×10^5	2.11×10^5	2.3×10^5	2.05×10^5
$E_o = \sqrt{(E + iR)^2 + (i,R)^2}$	527	459.3	481	453
% Regul = $\frac{E_o - E}{E}$ x 100	19.7	4.38	9.3	2.95
I^2R in feeder	18.0	1.42	5.25	.38
Line input K W	83.8	27.7	56.0	11.1
Line output K W	75.1	26.3	50.7	10.7
Line efficiency %	89.5	9.50	90.5	96.5
Total Load both phases K.W.	168	55.4	112	22.2

No. of feeder	5	6	7	8
Load on feeder KW	60.3	17.4	2.2	12.7
Distribution losses 1%	.6	.7	.2	.1
Losses in branches 1%	-	-	-	-
Transformation loss $2\frac{1}{2}$%	.5	.19	.1	.19
Total Load KW	61.4	17.8	2.5	13.0
P.F.	.9	.9	.9	.9
E	440	440	440	440
I	155	45	6.33	32.8
i	139	40.5	5.7	29.5
i,	67.5	19.6	2.76	14.3
R	.129	.40	.397	.45
iR	17.9	16.2	2.26	13.2
i,R	8.71	7.85	1.09	6.45
etir	457.9	456.2	442.6	453.2
$(E + iR)^2 + (i,R)^2$	2.1×10^5	2.08×10^5	1.96×10^5	2.05×10^5
$E_o = \sqrt{(E + iR)^2 + (i,R)^2}$	458	456	443	453
% Regul = $\frac{E_o - E}{E}$ x 100	4.1	3.6	.29	2.9
I^2R in feeder	3.1	.8;	.016	.49
Line input KW	64.5	18.6	2.52	13.5
Line output KW	61.5	17.8	2.5	13.0
Line efficiency %	95.0	95.5	99.5	96.5
Total Load both phases K.W.	129	37.2	5.04	27.0

Maximum Load, Continued.

No. of feeder	9	10	11	12
Load on feeder KW	3.48	18.4	20.15	7
Distribution Loss KW	.035	.20	.20	.07
Losses in branch feed	-	.28	.2	-
Transformation loss KW	.25	.05	.10	.05
Total Load KW	3.77	18.7	20.70	7.12
P.F.	.9	.9	.9	.9
E	440	440	440	440
I	9.52	47.2	52.3	18.0
i	8.56	42.5	47.0	16.2
i,	4.14	20.6	22.8	7.9
R	.63	.316	.062	.63
iR	5.40	13.4	2.92	10.2
i,R	2.60	6.5	1.41	4.98
e+ir	445.4	453.4	442.9	450.2
$(E\ iR)^2+(i,R)^2$	$1.98\text{x}10^{8}$	$2.05\text{x}10^{5}$	$1.96\text{x}10^{5}$	$20.3\text{x}10^{5}$
$E_o=\sqrt{(E+iR)^2+(i,R)^2}$	445	453	443	450
% Regul = $\frac{E_o-E \text{ x } 100}{E}$	1.1	2.95	.68	2.26
I^2R in feeder	.057	.70	.17	.20
Line input K W	.383	19.4	20.9	7.32
Line output K W	3.77	18.7	20.7	7.12
Line efficiency %	98.5	96.5	99.0	97.0
Total Load both phases K.W.	7.66	38.8	41.8	14.6

No. of feeder	13	14	15
Load on feeder KW	20.2	30	9
Distribution Loss KW	.2	.3	.09
Losses in branch feed	-	-	-
Transformation loss KW	.05	.13	.10
Total Load KW	20.5	3.43	9.20
P.F.	.9	.9	.9
E	440	440	440
I	51.8	8.66	2.33
i	46.6	7.8	2.1
i,	22.6	3.78	1.01
R	.237	.079	.031
iR	11.1	.616	.065
i,R	5.35	.298	.0313
E+iR	451.1	440.6	440.1
$(E\ iR)^2+(i,R)^2$	$2.04\text{x}10^{5}$	$1.94\text{x}10^{5}$	$1.94\text{x}10^{5}$
$E_o=\sqrt{E+iR)^2+(i,R)^2}$	451	441	440
% Regul = $\frac{(E_o-E)}{E}$ 100	2.5	.23	0
I^2R in feeder KW	.635	.006	.0002
Input KW	21.1	3.44	9.20
Output KW	20.5	3.43	9.2
Line efficiency %	97.0	99.6	100
Total Load, 2phases KW	42.2	6.88	18.4

The calculations show that the Agricultural feeder has the poorest regulation, 3.97% at peak load. The efficiency also is lower than that of any other, 92.3%. The regulations and efficiencies calculated for connected load show how impossible it would be to operate the system should the load actually rise to that value. The total connected load is 958.4 K.W. and the highest peak load is 277.6 K.W. of which 234.4 K.W. was metered at the power house Dec. 19th, and 43.2 K.W. is the estimated peak load of the feeders not fully loaded at that time. Then the ratio of peak load to connected load is 1 to 2.89, or the peak load is $\frac{277.6}{969}$ or 28.7 % of the connected load. In the regulation calculations at peak load the the total load of motors and lamps sums up to 260.6 K.W.

Several guesses as to this load were made, so as to obtain a value that when added to the losses would give about 277 K.W. for input. This was the most difficult part of the thesis, and much time was spent in determining this value of load at the lamp and motors. Taking 261 K.W. as the output of the distribution system, and 277 K.W. as the total input at the generating end, the over-all peak load efficiency of the distribution system is $\frac{260}{277}$ or 93.7 %.

The total illuminated floor space of all the University buildings is 721,250 sq. feet, and the total connected lighting load is 533.6 K.W. Hence the connected lighting load amounts to .740 watts per sq. ft. of floor space. Allowing 16 C.P. to 50 sq. ft. of floor would make the total candle power 203,800 or 14,425 16 C.P. lamps. There are actually 10,160 lamps of

candle power ranging from 8 to 100, carbon and Tungsten filaments. In the new buildings where tungsten lamps are used, the illumination is over 16 C.P. to 50 sq. ft. of floor while in the old buildings it is much less.

At this point it is well to estimate the cost of distribution. In figuring the cost of equipment, the cost of wiring was ommitted because it is always included in the cost of the buildings.

Cost of 13,300 ft. of No. 1 4 wire cable at $1145 per 1000 ft. =$15,200

Cost of 4,220 ft. of No. 64 wire cable at $1628 per 1000 ft. =$6,880

Total cost of cables $22,080.

Transformer capacity = 184 K.W.

Cost = $7.35 x K.W. 15 = 7.35 x 53 15 = $405 for transformers under 12 1/2 K.W.

Cost = 5.33 x K.W. 40 = .33 x 131 40 = $738

Total cost of transformers $1143.

8, 16 carbon lamps at $.16 = $1312

1943 tungsten lamps at $.60 = $1167

Total cost of motors is figured from the formula

$$C = \frac{53\ D}{(RPM)^{.3}}\ H.P.$$

Cost of motors aggregating 45 HP., 690 R.P.M. = $498

Cost of motors aggregating 946.5 HP, 900 R.P.M. =$2130

Cost of motors aggregating 80 H.P., 1100 R.P.M. = $579

Cost of motors aggregating 149 H.P., 1200 R.P.M. = $1033

Cost of motors aggregating 27.5 H.P. 1700 R.P.M. = $298

Cost of motors aggregating 11 H.P. 1800 R.P.M. = $186

Total cost of motors...................$5024

Cost of Motors	$5024
Cost of lamps	$2479
Cost of Cables	$22080
Cost of Trans.	$1143

Total cost of equipment $30,626

Allow 20% for labor of installing, switches, compensators etc., or $6,125

Total cost is $36,751

Int. depreciation and maintainance @ 15% = $5,500 per annum.

Int. depreciation etc., = $\frac{5500}{365}$ = $15.05 per 24 hr. day.

Average K.W. hr. load for 24 hr. day, = 1962.5 K.W. Hr.

Then cost of distributing and utilizing a kilowatt hour is $\frac{15.005}{1962.5}$ = $00767 or a little over a half a cent per K.W. hr.

Cost by losses per K.W. hr. distributed is $.0006. This added to $.00767 makes the total cost of distribution and utilization of a K.W. hr. equal to $.0083 or .83 cents per K.W. hr.

By examining last years load charts it was determined that the average dayload occurs about April 1st. to 10th., hence the watt hour meters on the feeders were read before and after 48 hours, and from this the watt hour consumption for 48 hours was found, and the total average load calculated. Following are the readings of the meters and the calculation of the load factor on basis of 24 hr. load.

Watt Hour Meter Readings.

Ag.&Farm Bldgs.		Chem.Bldg.		E.E.Lab.		Main Hall Nat.Hist.		Y.M.C.A.	
Ph. 1	Ph. 2	Ph.1	Ph. 2	Ph.1	Ph.2	Ph.1	Ph.2	Ph.1	Ph.2
33080	19430	88710	47310	11040	11170	33460	70020	14475	32795
33225	19590	88970	47450	11060	11235	53670	70300	14475	32895

Wood Shop		Gymnasium		Womans Bldg		Library		Physics	
Ph. 1	Ph. 2	Ph.1	Ph. 2	Ph.1	Ph. 2	Ph.1	Ph.2	Ph.1	Ph.2
6766.0	2003.0	3303.0	32135	56725	43505	57880	84525	52600	23055
6847.0	2104.0	3307.0	32460	57275	44890	61570	99645	22740	23190

Eng'g Bldg.		T&AM Lab.		M.E.Shop		M.E. Lab.			
Ph. 1	Ph. 2	Ph.1	Ph. 2	Ph.1	Ph.2	Ph.1	Ph.2	Ph.1	Ph.2
14850	7956	6031	3271	605	9961	5723	5373		
1528.5	80140	6113	3288	726	95.5	6070	5693		

LOAD

	AG&Farm Bldgs.		Chem. Bldg		E.E.Lab.		Main Hall Nat.Hist.		Y.M.C.A.	
	Ph. 1	Ph. 2	Ph.1	Ph.2	Ph.1	Ph. 2	Ph.1	Ph. 2	Ph.1	Ph. 2
48 Hrs	145	160	260	140	20	65	210	280	0	100
24 Hrs	72.5	80	130	70	10	32.5	105	140	0	50

	Wood Shop		Gymnasium		Womans Bldg		Library		Physics	
	Ph. 1	Ph. 2	Ph.1	Ph.2	Ph.1	Ph. 2	Ph.1	Ph.2	Ph.1	Ph.2
48 Hrs	81.0	101.0	4	32.5	55	138.5	369	412	140	135
24 Hrs	40.5	50.5	2	16.25	27.5	69.25	184.5	206	70	62.5

	Eng'g Bldg.		T&AM Lab.		M.E.Shop		M.E. Lab.			
	Ph. 1	Ph. 2	Ph.1	Ph.2	Ph.1	Ph. 2	Ph.1	Ph.2	Ph.1	Ph.2
48 Hrs	43.5	58	82	17	121	134.5	347	.320		
24 Hrs	21.75	29	41	8.5	60.5	67.25	173.5	160		

LOAD FACTOR.

General Capacity 295 K W

Connected Load = 969 K W

K W H R Load For 24 Hrs. = 1962.5

Load Factor By General Capacity

$$\text{Load Factor} = \frac{1962.5}{295\text{x}24} = \frac{1962.5}{7080} = 27.7 \text{ Per Cent.}$$

Load Factor By Connected Load.

$$\text{Load factor} = \frac{1962.5}{969\text{x}24} = 8.45 \text{ per cent.}$$

Recommendations for Improvements.

As was before mentioned the regulation of the feeders, except the Agricultural feeder, is very, good but the curve of voltage taken in connection with the load curves show that the voltage at the generators is very unsteady. It varies from 430 to 480 volts during the day yet the average regulation of the feeders is about 2% at peak load. The low power factor of the load is the direct cause of the change in voltage, because the large "lagging currents" demagnetize the generators and thus cut down the voltage very much. When the switch board attendant sees the drop in voltage he raises the excitation to a point considerably above normal, and when the lagging load is cut off the voltage of the machine rises far above normal.

It is thus evident that an automatic regulator is badly needed for the generators. The plan of the University Authorities is to run a three phase 2300 volt feeder from the new power plant to Lincoln Hall, which is in process of construction, putting the lighting load of this building on one phase of the low tension, side of the 2300-220-110 volt transformers, and regulate the voltage of this phase, with a Tirrill regulator. The Turbo unit runs in parallel with one of the two phase generators so that one regulator could be used for both machines. We do not think it a good plan to put the regulator on the Lincoln Hall feeder, especially if the current transformer is used to increase the voltage 4 or 5% at

heavy load. The regulation of the voltage on the single phase lighting circuit of this feeder will not secure accurate regulation on the other feeders, because when the load is light on the Lincoln Hall feeders it may be heavy on some of the others. When this is the case the regulator will keep the generator voltage at 440 volts, while the voltage at the receiving end will be 3 or 4% lower due to the drop in the line. The Lincoln Hall feeder has a very small regulation, about 1.1% so that even if it was loaded it would not raise the voltage sufficiently on the other feeders to overcome their regulation at peak load.

There are two better places to put the current transformer of the regulator; one is on the generator bus-bars, and the other is on an average feeder, that is, one having an average regulation, and one having its peak load at about the same time that the others do. Referring to the calculated results it is seen that the average regulation is about 1.4% and the Hydraulics Laboratory comes nearest to this figure. Besides, the Hydraulic Laboratory feeder carries considerable motor load, has its peak load about 2.30 P.M. in the fall and spring and at 5.00 P.M. in winter. So that if the regulator is put on this feeder with both current and potential regulation it would keep the generator voltage constant, and raise it 1.4% at time of peak load. To accomodate the heavy feeders the regulator may be adjusted to raise the voltage more than 1.4% at peak load, say 2% or an induction regulator may be used to raise the voltage 3 or 4% on the

three heaviest feeders.

In case it is not desirable to use a current transformer in connection with the regulator, another plan can be followed, which we think is excellent as a means of immediate improvement. The plan is as follows. Put enough feeders that have only lighting load on one of the two phase machines, say the 75 K.W. generator, so as to load it fairly.
Put all the other feeders carrying motor lighting load on the other two machines which run in parallel. and put the regulator on one of the feeders supplied by these two machines, say the Natural History feeder. Put on the potential transformer and let the regulator hold the voltage of both parallel machines constant at normal voltage at all times except peak load.
Now, on the regulator is a small rheostat with several buttons, and by moving the handle up onto any one of the buttons the voltage will be raised a certain amount, the steps usually are per cents of the normal voltage. So when the time for peak load approaches, the switch board attendant can adjust the rheostat so as to get any desirable increase in voltage.
The average regulation in the heavy feeders carrying motors and lighting load is 2.% hence a 2 to 3% increase is sufficient.
The generator which runs singly carrying lighting load will have no lagging current to demagnetize its field and lower its voltage, hence a Tirrill regulator is not needed here.
At the time of peak load on these lighting feeders, say 5.00 P.M. , the attendant can raise the voltage of this generator say 3/4 to 1% by means of the generator field

rheostat. At times of light day load one of the parallel machines may be stopped, or the load of the single machine may be put on the machine running in parallel. At night any machine may be used to carry the load since no motors are running. ~~to~~ Feeders carrying motor load should be put on the machine operating without the regulator, their these will be no trouble about fluctuating voltage.

When more buildings are constructed beyond the Auditorium, as they probably will be in the near future, three-phase 2300 volt transmission only should be used, and the feeder supplying these buildings can also supply the Farm buildings, taking much of the load off of the Agricultural feeder which is very heavily loaded at present.

A serious fault of the system is that there are entirely too many transformers in use, there being about 50 in all. The Boiler Room, M.E. Lab., Pump Station and E.E. Lab. could easily be supplied from two auto transformers to great advantage. The M.E. Shops, would also be included in this group. The Farm buildings, the Old and New Nat. Hist. buildings and many others could be grouped also.
The following is a scheme of grouping that is suggested by the writers.

Group 1
E. E. Lab.
M. E. Lab.
M. E. Shop
Hydraulic Lab.
Boiler room
Pump Station
Green House

Group II
Eng. Hall
Physics
Presidents House

Group III
Main Hall
Library

Group IV
Law Building
Nat. Hist.
Chemistry

Group V
Agricultural Bldg.
Entomology
Suditorium
Observatory

Group VI- No's 25, 26, 27, 28, 30, 31, 36, 37, on blue print of buildings and grounds. If it is desired to use 2300 volt transmission, the above grouping with one set of transformers for each group would be the only economical and logical way in which to arrange the circuits. This would make three main feeders: say, one feeder for buildings north of power house, and two for buildings south, one for buildings along the east side of the campus, south of the power house, and one for those along the west side. The buildings near the center of the campus being divided equally between the latter two. Having three feeders instead of 16 would certainly simplify the switch board connections. However, this change would involve a tremendous expense, and would hardly be justifiable

unless the load were to increase 100 to 200%.

The power factor is so low because there are so many motors that are running under loaded, and a table is given in Part I showing what motors may be replaced to advantage by smaller ones. There is one 5 H.P. motor in the Plant Breeding Labratory in the Ag. building which has no starting compensator, it simply starts by closing a four pole knife switch. This is objectionable, and also dangerous; objectionable because the voltage at the generator is lowered as much as 15% when an induction motor on the line is started without a compensator should attempt to start the motor when the load was on or the rotor was stuck, a heavy current would flow, blowing a fuse and possibly burning out the motor. Money spent for a starting eompensator is well invested.

The collected data shows that some of the transformers have no protective device on the high tension side. Every transformer should have fuses and also a high tension switch or cutout, so that the building can be disconnected in case of fire, so as to prevent a short circuit. A switch also would facilitate in the removal of a transformer to save it from being burned. Also some transformers are dangerous as to life and fire risk. The transformers for the new Natural History building are set on the floor along the wall of the passage way into the tunnel and it would be very easy for a man to stumble and fall over them. Those that are hung on wooden posts under the floors are very apt to cause fire should they burn out or their leads be broken loose. A transformer under the Armory floor is fastened to a wooden post by one

loose nail.

The watthour readings used in determining the load factor show that on some of the feeders the load is very much unbalanced between phases, in spite of the attempt to balance the load by connecting the neutrials of the auto transformers. When one building is put on one phase and another building on the other phase, the load cannot be balanced by connected neutrials when one building takes much more load than the other, because with an unbalanced load, considerable current flows through the neutrials, and from one neutrial to the other, and they through the auto transformer windings. The capacity of these transformers is about 5% of the actual load, hence the winding is of small wire, and not very much current can flow through it, hence unbalancing results. Furthermore, the transformer losses in cases of this kind are very high, and they are liable to become over heated. It is therefore desirable that each building be supplied by both phases. unless it should incur to great a change in the wiring of the building.

Whereever 110 volt circuits are used it would be economical to install tungsten lamps, but the complaint is that these lamps are being stolen, making it unprofitable to use them. If some practical scheme could be effected to prevent stealing the lamps, the difficulty would be solved. It may pay to protect each lamp by soldering small lugs with holes in them, one to the base of the lamp at the edge of the glass and the other to the edge of the socket. The lugs could be placed in such a position that when the lamp is screwed into the

socket the holes in the lugs will cover each other, and a small ten cent padlock could be put through so that the lamps cannot be removed unless the lock is opened. It would cost perhaps 16 cents per lamp to put this device on each tungsten lamp, and would save many dollars in new ones.

The campus is illuminated by old fashioned 9.6 ampere D.C. series open arc lights supplied by a D.C. arclight generator, of the high voltage type.
Despite the age of this system, the efficiency of these lamps in watts per candle can hardly be improved upon by our modern arcs. By installing 6.6 ampere A.C. enclosed series lamps they could be operated from an arc light transformer in the power house. This would do away with the arc generator which is very troublesome at times. There are seven of these arc lights, and seven new 6.6 amp. A.C. enclosed arcs would cost x3.20 or $22.40, and the transformer would cost about $30.00, hence the cost of a new arc light system would not be very much.

In this thesis no report has been made on the Direct Current system. There is an 85 K.W. 220-110 volt 3 wire generator in the power house with distribution leads to some of the buildings where a small amount of continuous current is used. Since it is the immediate intention of the University authorities to install small motor generator sets at different distribution points, no attempt has been made to give recomendations along this line, since this plan cannot well be improved upon, in the writers estimation. It is

strange that steps have not been taken long ago to secure better voltage regulations of the system.

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